



**Carnegie Mellon
Software Engineering Institute**

Why Not Network Centric Acquisition?

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Topics to be Covered

Lessons Learned from Iraq: The Need for Continued Transformation and Network Centricism

Network Centric Warfare (NCW)

Network Centric Acquisition (NCA)

Breakthroughs in Technology: The Military's Role in the Evolution of Complex Technological Systems

Keys to Realizing NCA

Envisioning NCA in Practice:
Army Strategic Software Improvement Program (ASSIP)



Lessons Learned in Iraq

Operations Enduring/Iraqi Freedom

- Showed that interdependency and interoperability reduce sensing-to-decision-to-engagement time
- Confirmed that Military Transformation is on the right track

That “lessons from fighting insurgents [are] mostly negative,” also confirms the need for **Continued Transformation**.

Loren B. Thompson, Lexington Institute Georgetown University, November 18, 2003

Continuing Transformation must cast a more comprehensive net for a **Future Army** more adapted to its ecology.



Lessons Learned for Transformation

Lessons for Transformation include:

- Clearly identifying the enemy by *new emphasis on intelligence, cultural sensitivity and information processing.*
- Countering an enemy's adaptability to technologies by *spiraling in refinements/replacements across doctrine, organizations, training, acquisition, personnel and facilities.*
- Preparing for new forms of military conflict *using modular organizational constructs networked to fit very different situations.*
- Utilizing the criticality of the network by *conducting information operations that both exploit it and keep it secure.*

Adapted from "The Army in 2020" White Paper by John M. Riggs



The Future Army will be Network Centric

The Army is becoming **Network Centric** as networks become more the center of attention.

As this continues, everything the Army does will be **Network Centric**, including its:

- Operations
- Doctrine
- Organizations
- Training, Leaders and Education
- Personnel
- Facilities
- **Acquisition**

The Future will have a Joint, **Network Centric** “mindset.”

Adopted from “*The Army in 2020*” White Paper by LTG John M. Riggs

Network Centricism

Being Network Centric is

- taking the form of complex system that puts networks center stage
- based on both military and commercial development and use of communication, information and network technologies
- derived from experience of developing/using the Internet.

Nodes in network centric systems are:

- relatively autonomous and can act rapidly and effectively
- almost always networks themselves
- constrained by their place in the network.



What is Network Centric Warfare?

NCW is the application of a networked force to achieve a decisive warfighting advantage.

NCW translates information superiority into superior combat power.

Characterized by:

- effectively linking friendly forces against enemy forces
- shared awareness between decision makers and soldiers
- increased speed of command
- More discrete control over tempo of operations
- greater force effectiveness
- increased adaptability (as a complex adaptive system)
- a degree of self-synchronization or self organization.

Controlled by:

- Body of doctrine to support the actions
- Communication among subunits facilitating self-organizing
- Clear commander's intent sensitive to both negative and positive feed-back

Arthur K. Cebrowski, Network Centric Warfare, Military Technology, MILTEC 5/2003



How is NCW Doing – In Iraq

What can be learned:

- The war is not over. Lessons will look a lot different depending on outcomes.
- Many significant lessons will remain secret.
- Review process may be subject to Transformation bias and other perspective bias.

Lessons up to now are that some capabilities were:

- high performing – joint integration/adaptive planning, joint force synergy, special ops integration (SATCOM, ADOCS)
- effective but need improvement – urban operations, ISR (SBIRS, Global Hawk, JSTARS, ABCS effective in command centers but not always for troops)
- not up to expectations or needs – fratricide prevention, deployment planning and execution, reserve mobilization, troops often missing visual displays (SIGINT)

Since conventional combat ended, U.S. forces have faced growing guerrilla resistance – lessons mostly negative.

Iraq experience validates Cebrowski view that networked warfare isn't just about technology.

See “Lessons of Iraq,” by Loren B. Thompson, Lexington Institute, 11/03
Joint Forces Command Study, 8/03

What is Network Centric Acquisition

Network Centric Acquisition can...

- avoid redundant costs by supporting achievement of commonality
- facilitate interoperability
- provide resources and infrastructure for evolutionary upgrades
- shorten response times to provide technology when under threat
- ensure preparedness by designing industrial base partnerships

...by leveraging **communication**, **information** and **network** technologies to:

- design and enter into new partnerships – services, industrial base and multi-national
- capture experience and information that can be turned into actionable knowledge both
 - internally through organizational learning and experience factories
 - Inter-organizationally via joint risk management and libraries of reusable software.

See “Network-Centric Acquisition: The Key to Joint Warfighting,” by R.A. Lefande, DAU PM 2002

Can Current Acquisition Achieve NCA

Challenge from VADM Cebrowski (Director of DoD's Force Transformation): "The operational side is agile, adaptive and high speed; whereas the acquisition side is very ponderous, not agile, time lines are long and response problematic." (*Inside the Navy* 11/02)

Operational Acquisition: Soldiers fighting in Operation Enduring Freedom identified the need to confront underground targets through use of rapid development of thermobaric weapons used in Afghanistan.

Because this was on the operational side, versions of the weapon were developed and delivered quickly. (Cebrowski, *Inside the Navy* 11/02)

Can the Acquisition Side Deliver?

Other NCA Issues

NCA has many issues in common with acquiring Complex System of Systems (CSOS)

(Boehm and Basili, (Complex System of Systems - CSOS, SIS Acquisition Conference, 2003).

- **Does managing CSOS projects via Lead System Integrators (LSIs) work?**

Little experience so far and the jury is not in.

Some CSOS have been tested, successfully fielded, refined and evolved without an LSI and without any show-stopping problems.

- **Is the complexity of CSOS manageable by standard software engineering practices?**

Conflict between and number of quality attributes makes tradeoff analysis very difficult.

Number of and interlinking of software modules makes creating and changing the software and the software architecture very difficult

- **Is there something to learn from looking at CSOS as Complex Adaptive Systems?**

Perhaps they are amenable to a degree of self organization involving new, perhaps more open-ended, forms of partnership.



Present Acquisition Structure Issues

The goal of equipping a Joint Force to prepare for NCW is impeded by:

- separated Services broken down into Programs and PEOs specializing in particular kinds of warfare product or product line
 - usually no interoperability across products within a PEO, let alone product lines within and across PEOs and services
 - redundancy of products and product lines across Programs, PEOs and Services
- Congress' insistence on the auditable separateness of the Programs and contract awards traced to their districts.

Targeting Software to Achieve NCA

Software

- has no production phase – the design, development and documentation of the software is the product
- can insure interoperability but is also the primary cause of failed interoperability
- is redundantly developed at the subsystem level, and this is tolerated so that risk can be transferred to the contractor.

If the government owns the design, source code and documentation resulting from the development of the software, it is possible to

- make the software available in an online library where it can become standardized for reuse
- define a common “what, where and when” standard enabling exchange of this type of data with any other system that makes the same investment.

See “Network-Centric Acquisition: The Key to Joint Warfighting,” by R.A. Lefande, DAU PM 2002

See “A Few Choice Words Can Make Network-Centric Warfare a Reality Today,” by Rich Byrne ,
www.afcea.org/signal



Software Changes the Essence of Systems

“Well designed and implemented software can be changed in minutes or hours versus the weeks and months required for hardware modification, thus permitting flexibility to address rapidly evolving mission requirements.”

“... software governs most of the interfaces of today's systems [which because of] [t]he flexibility of software enables us to quickly integrate separately developed systems permitting ... horizontal integration primarily through effective software application.”

“...software enables systems to adapt to new environments, new threats, and new concepts of operation. This adaptability is a key enabler to reaping the benefits of rapid technological change and providing the transformational battlefield envisioned by Joint Vision 2020”

John M. Gilligan, “Military Use Software,” Department of the Air Force, CrossTalk 01/04

SW Intensive Systems Need Discipline...

The flexibility to

- address rapidly evolving mission requirements
- quickly integrate separately developed systems
- adapt to new environments, new threats, and new concepts of operation (John M. Gilligan, CrossTalk 01/04)

may require modification of discipline to fit the new context.

Otherwise,

- unrealistic expectations of what can be accomplished through software and data interoperability
- the quickness of modifying software will have untoward impacts on architecture, configuration management and testing.



... Even a New Form of Discipline

The impact of software on complex technology systems has not been sufficiently understood by PMs, Contractors or even the Software and Systems Engineering disciplines.

Software is not simply one component among others.

New software capabilities and discipline have to be integrated into overall systems engineering processes.

What is needed is an interdisciplinary culture of software professionals with a complex software intensive system enterprise perspective.



All Complex Technological Systems are Networks

An important historical lesson is that all complex technological systems can be described as networks.

(see Thomas Hughes, *American Genesis* and also *Rescuing Prometheus*)

Many of these complex technological systems have been built by military sponsored or supported projects.

Examples from World War II and after are:

- Manhattan Project
- SAGE
- Atlas
- ARPANET



Network Centric Systems are Software Intensive Systems

After World War II, complex technological systems began to be infused with a new kind of technology, software, that changed the essence of systems.

From that point on, complex technological systems were typically software intensive systems.

Software is capable of networking relatively stand-alone **technical** systems into systems of systems.

Software intensive systems support linking stand-alone **organizations** into networks of learning enterprises but only if social factors are central to the design.

These technical and social networks co-evolve as Network Centric Systems (NCSs).

Perhaps the paradigm of a network centric/software intensive system (NC/SIS) project was the ARPANET.



ARPANET: Network Centric/Software Intensive

Packet Switching

- ARPA-IPTO – sufficient resources in the 60s and 70s to provide the necessary “glue” for building, operating and extending the Internet

Layering – Communications (IMPs and Routing), Hosts, Applications (email)

- Routing was self-adaptive in that each IMP “decided” independently where to send packets adapting to changes in network configuration and traffic.

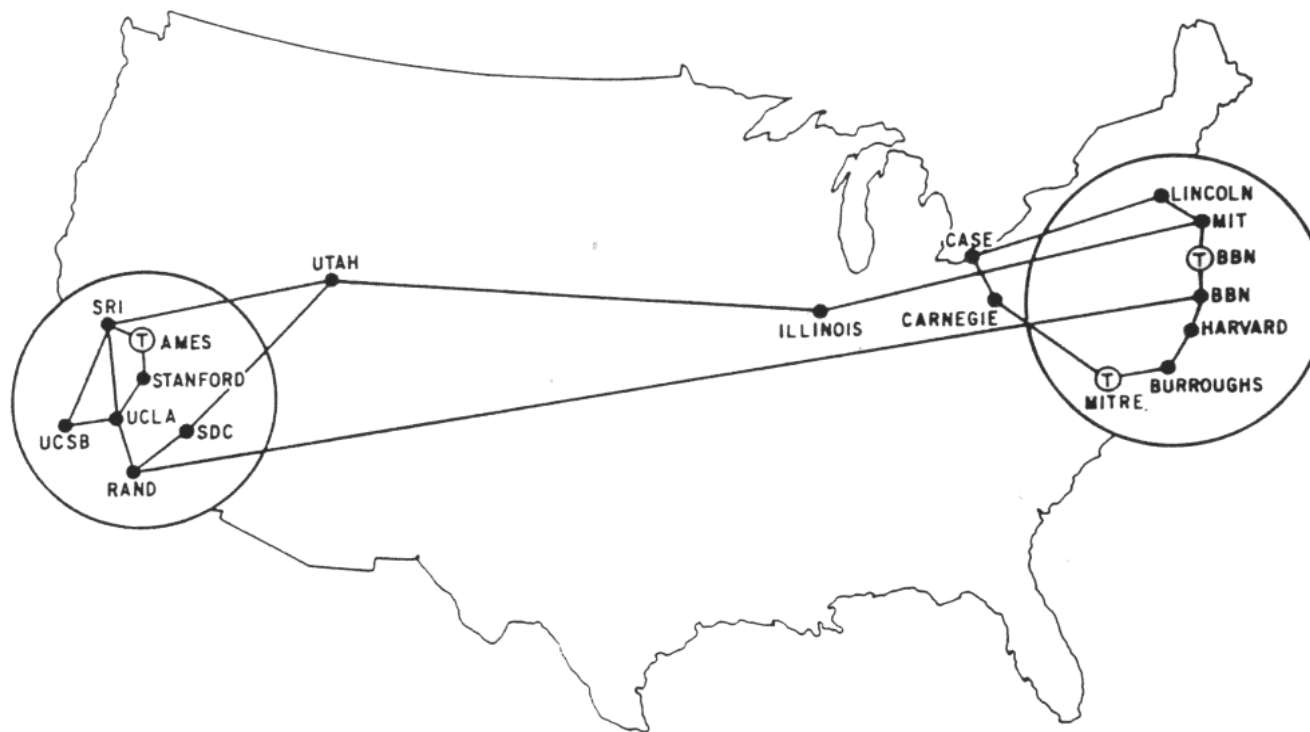
Development (ARPA supported BBN, UCLA, NAC)

- Network Working Group’s Requests for Comments – Body of Knowledge via the ARPANET and evolving standards informally (telnet, ftp...)

Deploy, Operate and Refine (Significant User Involvement)



ARPANET 1971



MAP 4 September 1971



ARPANET Users

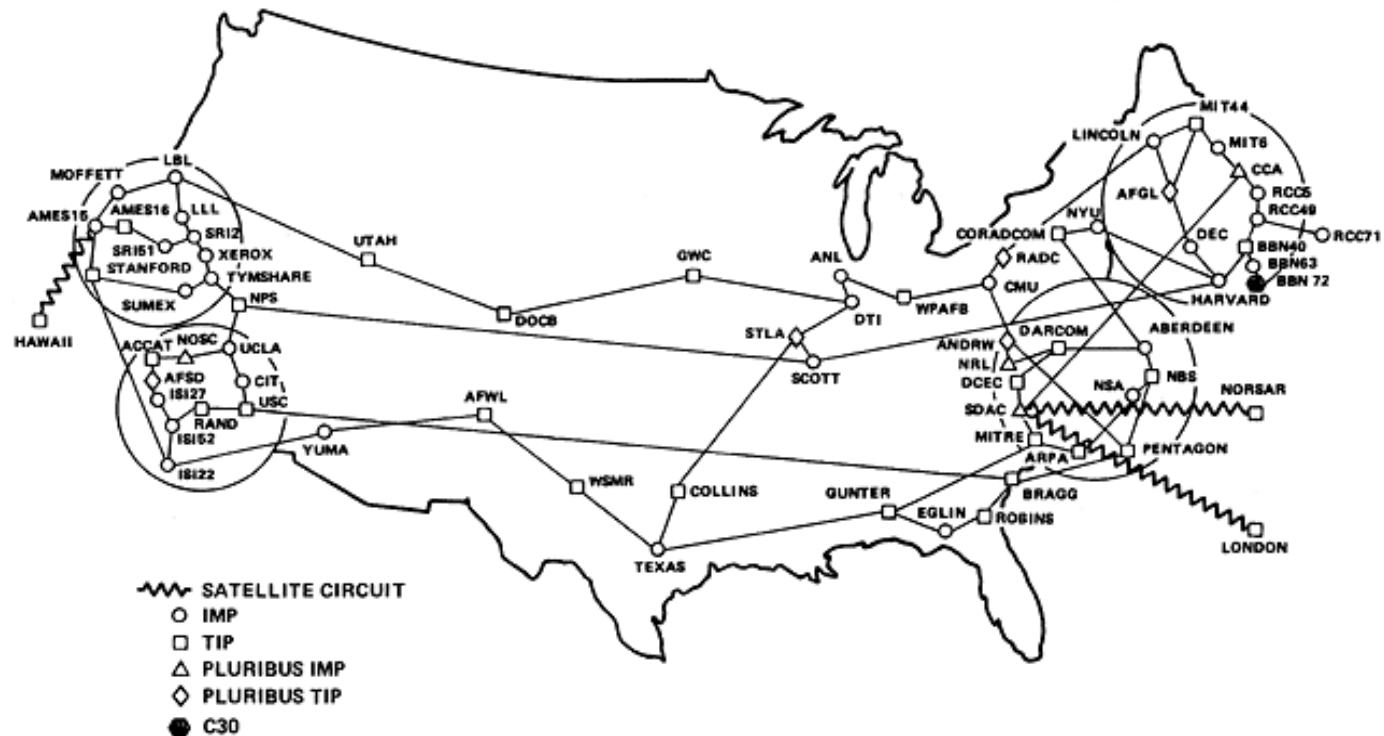
Users significantly transformed the ARPANET

- Developed alternative terminal interface systems which ARPA began to fund.
- Replaced resource sharing and distributed computing unexpectedly with *email* as the service of choice.
- Created tools for accounting and editing.



ARPANET 1980

ARPANET GEOGRAPHIC MAP, OCTOBER 1980

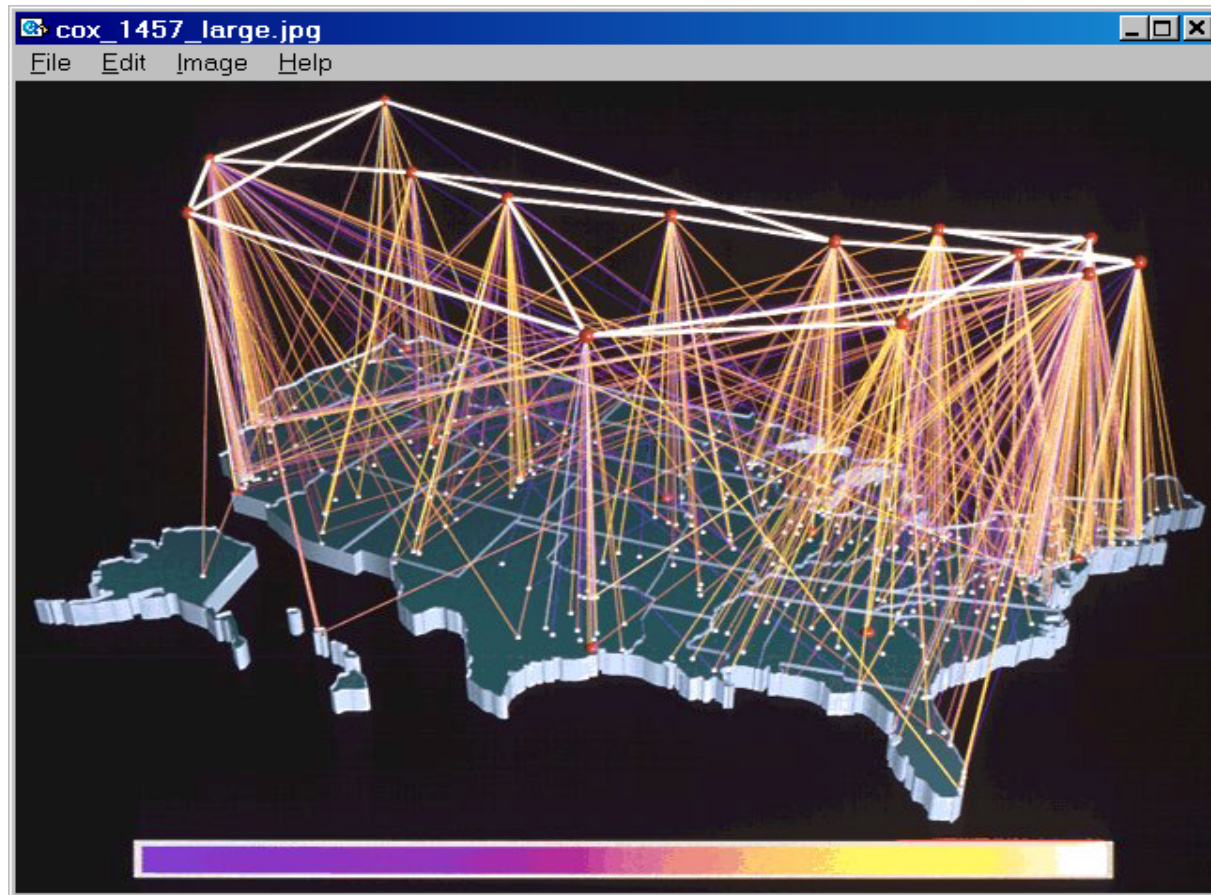


(NOTE: THIS MAP DOES NOT SHOW ARPA'S EXPERIMENTAL SATELLITE CONNECTIONS)
NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES



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Visualization Study of the NSFNET, Donna Cox and Robert Patterson 1992





The ARPANET Became Part of the Social Network that was Creating It

Just as the ARPANET co-evolves and integrates with the network using and building it...

...so too network centric technologies co-evolve and integrate with their NCW users...

...and other network centric technologies co-evolve and integrate with their NCA participants.

Similarly, NCW has to co-evolve and integrate with NCA.



ARPANET and Internet Successes...

Managing, developing and using the ARPANET (and eventually the Internet) stemmed from and extended a culture that

- Avoided the sort of High Control that imposes
 - needless layers of bureaucracy that interferes with the delivery of needed capabilities
 - elaborate procedural models where lighter-weight methods can be applied
- Encouraged Agile Control by encouraging new
 - forms of information-sharing, communication and participation
 - ways of forming virtual teams, organizations and co-laboratories
 - use of the ARPANET to build bodies of knowledge (RFCs)
 - approaches of evolving standards informally



...also Brought Potential Failures...

These potential failures are now targeted in the rise of:

- a security industry needed for network survivability
- new forms of software engineering to handle the immense expectations and risks of networking various weapons and C⁴I capabilities into systems of systems
- a large literature on organizational and inter-organizational learning from risk and failure.



Are Networks and Communities That Learn from Failure: The Key?

Network Centric Systems (NCSs) like other innovative complex technological systems grow or die according to how well they address repeated failures.

NCSs may fail more but they also can provide more timely and sustained support for learning from failure and making corrections.

Responding to repeated failures requires knowledge creating communities and knowledge networks.

These new social environments of joint learning can be powerfully supported by knowledge bases and experience factories of failures, successes, risks and opportunities.



Boundary Spanning Learning

Historians of technology have repeatedly found that the locus of technological knowledge spans across:

- Disciplines
- Organizations
- Policy Makers
- Producers
- Users

Examples are:

- American inventor entrepreneurs (like Sperry etc.) who used patents as indicators of open problems and the leading edge of invention
- ARPANET builders/users who participated in the Network Working Group through exchange of Requests for Comments over the ARPANET



Inter-Organizational Learning and Knowledge Networks

- Complex technological systems like the ARPANET are produced by projects.
- The knowledge created in these complex technological projects is often disseminated through the circulation of people.
- This knowledge can be more durably circulated if the inter-organizational partnerships forged in the projects are maintained through longer term alliances.
- There are many examples of such knowledge networks or virtual organizations in the bio-technology and computer/software industry.



Taking Steps Toward NCA

“Integration of software into our overall system engineering processes requires a new culture with a strong emphasis on training and education and a focus on the integrated enterprise as the target environment.”

(John M. Gilligan, Department of the Air Force).

How might such a culture of more durable enterprise knowledge be built?

By combining,

- new types of partnerships with
- boundary spanning networks and
- information and network technologies

durable knowledge networks and the new culture could result.

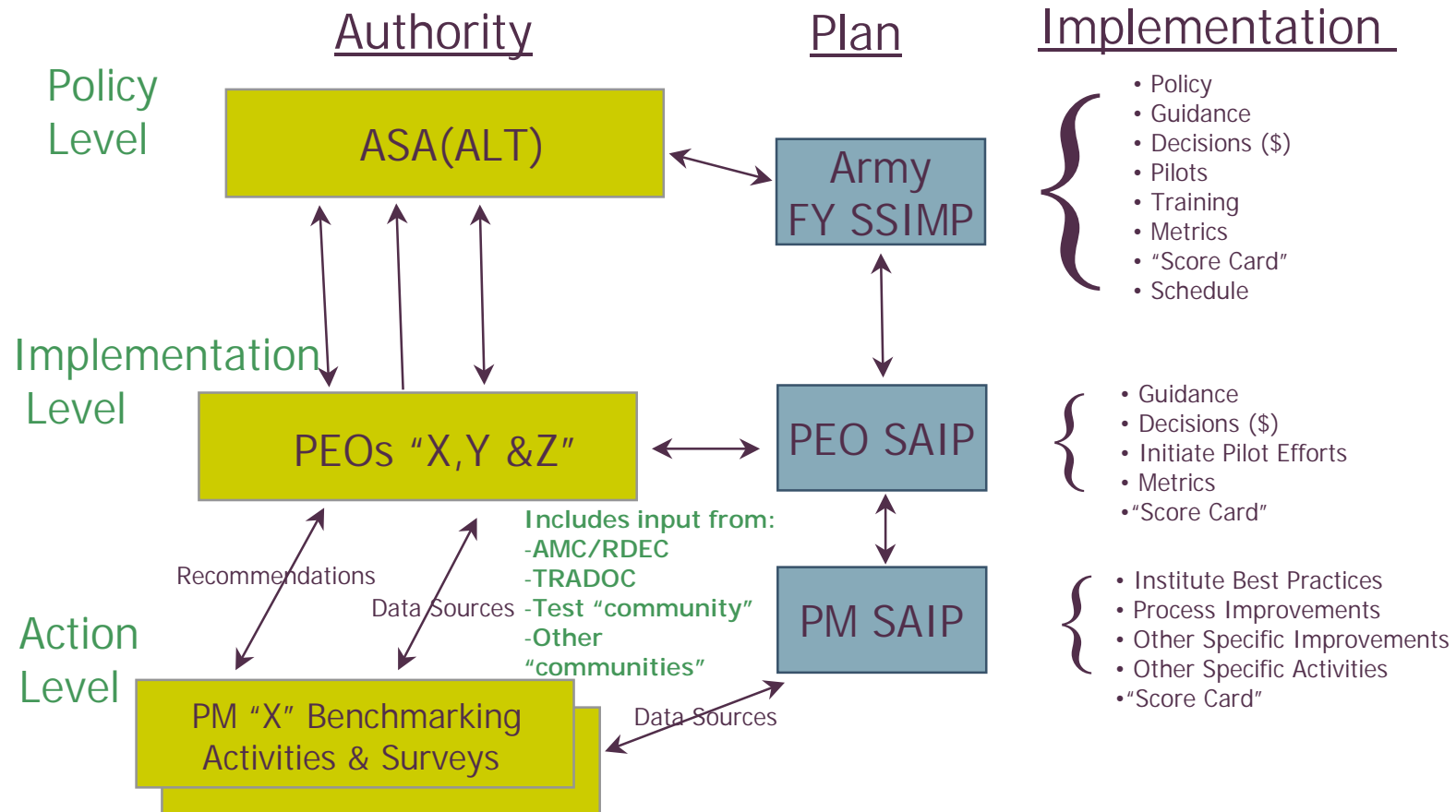
It might therefore be feasible and beneficial for the Army if the *Army Software Systems Improvement Program (ASSIP)* would help create such an Army Knowledge Network (AKN).



ASSIP Recent History and Desired Outcomes

- Fall of 2002 – ASA(ALT) agrees with SEI to execute the *Army Software Systems Improvement Plan (ASSIP)*; with a '02 – '09 target
- The ASSIP calls for –
“Dramatically Improving the Acquisition of Army Software Intensive Systems”
- Task scope is Army – or Enterprise-Wide
- ASSIP calls for:
 - Inter-organizational perspectives
 - Virtual-organizational applications
 - Made up of Army Acquisition community components

The Network Structure of ASSIP





ASSIP as a Learning Enterprise: Scaffolding for a Story to Come?

- ASSIP concept provides an executable structure
- ASSIP concept is identifying a set of acquisition “Benchmarks”
- ASSIP concept provides a forum for crafting SIS acquisition improvement
- ASSIP structure produces an actionable plan for each FY
- ASSIP responds to Section 804 guidance



The Challenge Remains

- The Operational components of the DOD are embracing NCW as a means to attain the goals of Joint 2020 through Transformation.
- The Acquisition components of the DOD should consider the potential of concepts such as those driving NCW and Transformation to attain similar goals.
- While the future is yet to be realized, work is beginning across the Services.